Comparison of Mathematical Learning Capabilities Among Students Using the Reciprocal Teaching and Problem Posing Model

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Abstract

The purpose of this study is to ascertain whether students who learn to utilize the reciprocal teaching model have a greater understanding of mathematical topics than students who learn to use the problem posing approach. This research was carried out at SMP Negeri 97 Jakarta for seventh grade students on the subject of Persamaan Linear Satu Variabel (PLSV). This study was conducted using a quasi-experimental design. A two-stage random sampling method was employed for the sampling process.The first stage is purposive sampling, in this case three classes are selected which are taught by the same teacher. Then the second stage is cluster random sampling, from three classes that are normally distributed, homogeneous and have the same average, two classes are randomly selected as experimental class I (reciprocal teaching model) and experimental class II (problem posing model). The research instrument used was the final test of the ability to understand mathematical concepts on the subject of PLSV as many as 6 questions. Validity testing uses content, construct, and empirical validity. Calculation of the reliability of the instrument using the Cronbach Alpha correlation formula and obtained a reliability coefficient of 0.714 which is classified as high. The research hypothesis was tested using t-test statistics.The result show that the ability to understand mathematical concepts of students who learn to use the reciprocal teaching model is higher than problem posing model.

Key words: reciprocal teaching, problem posing learning, mathematical concept ability

INTRODUCTION

Mathematics is a subject area that has a significant impact on schooling. This can be seen through the existence of mathematics subjects in every educational unit, from elementary school to university. The ability to understand mathematical concepts is one of the skills needed by students because mathematics teaches about interrelated patterns and sequences. If the student has understood a mathematical concept, it will be easy for the student to learn the next more complex mathematical concept. The importance of understanding concepts in mathematics is also emphasized by Zulkardi who state that mathematics subjects emphasize concepts (Herawati et.al., 2010). Students can build skills and creative thinking through a solid conceptual grasp, which will ultimately enable them to tackle existing mathematics issues. Therefore, the important goal of learning mathematics is to make students understand concepts, not just memorize facts, procedures, and algorithms.

However, in practice, Indonesian students still have a limited understanding of mathematical ideas. Suratman's research stated that students' understanding of mathematical concepts was still low (Suratman, 2010) . This can be seen from the answers of junior high school students in Singkawang, students who are able to answer correctly are 26.37%. Because the number of percentages still displays the figure$< 55\%$, this percentage show that students' conceptual grasp is still quite low. In addition, the study revealed that students' conceptual understanding abilities were lower than their procedural knowledge. One of the causes of the low understanding of concepts compared to students' procedural knowledge is because students are used to solving routine problems that only require algorithms and repetition, not developing concepts from the material itself.

Furthermore, to see the ability to understand students' mathematical concepts on a smaller scale, observations were made in one of junior high school in Jakarta. In the learning process, the teacher explained new material to students, then students were given examples and practice questions related to the material. However, teachers often provide practice questions that are relatively the same as the examples of questions given previously. This causes students to tend to only memorize formulas and follow the example questions given by the teacher without interpreting them. This means that when students are given questions that are different from the questions the teacher usually gives, the majority of students cannot solve the problem. It is impossible to isolate the issue of teachers not being able to comprehend the mathematical concepts of their students from the classroom learning activities.The teacher is used to explaining the material in the form of formulas and concepts that must be memorized by students. This resulted in students being passive in class and not knowing how the mathematical concepts were obtained. Whereas students should be given the opportunity to actively participate in the teaching and learning process. The activeness of students will lead to motivation in students to learn by finding the basic concepts of science based on their own hypotheses.

The new paradigm of learning that is currently being developed is student-centered learning. In student-centered learning, the teacher is no longer the only source of knowledge for the students; instead, the instructor's role is to support the students' learning in this situation. Students in student-centered learning are given the opportunity to be able to express their ideas and accept the ideas of others. In addition, students are also given the opportunity to be able to bring out all their abilities to examine more deeply a problem given by the teacher. Thus, The goal of student-centered learning in mathematics instruction is to encourage students to become more adept at comprehending mathematical ideas.

In this light, employing constructivism in education is one way to develop student-centered learning. This is based on the principle contained in constructivist learning theory that teachers not only provide knowledge to students but that students also have to build their own knowledge in their minds (Suryono & Hariyanto, 2012). Students are no longer positioned as empty vessels ready to be filled. Teachers are not the only information centers and they know best. This constructivism learning can be applied with a variety of learning models, including the reverse learning model (reciprocal teaching) and the problem posing model.

The fundamental tenets of constructivism are in line with reciprocal teaching, which prioritizes students' active participation in developing their thought processes (Sujati, 2005). Students actively participate in the learning process through 4 strategies as stated by Palinscar and Brown, namely making questions (question generating), clarifying terms that are difficult to understand (clarifying), predicting advanced material (predicting), and summarizing (Palinscar & Brown, 1984). Teachers in reciprocal teaching learning act as facilitators, mediators, and managers in the learning process.

The implementation of this reciprocal teaching is anticipated to improve students' understanding of mathematical concepts. This is because when students are able to develop the steps in reciprocal teaching, it means that students can find and investigate the material discussed independently, so that the outcomes will stick with students' memories and not be readily forgotten by them. By finding the material independently, students' understanding of a concept is an understanding that is truly understood by students. This is in accordance with research conducted by Suantak and Saleh (Suantak & Saleh, 2015) .Suantak and Saleh stated that reciprocal teaching can improve students' understanding of mathematical concepts.

One of the learning models that is in line with the basic principles of constructivism is problem posing (Rosil et.al., 2014). Problem posing is a learning model that is carried out by involving students directly in formulating, making, and solving problems based on the material that has been studied. Problem posing can teach students how to compile their own questions or break down complex problems into simpler questions that refer to the solution. The teacher only acts as a facilitator to guide and direct students to understand the questions presented and the variations that may be formed from

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these questions. Learning mathematics through problem posing includes two kinds of activities, namely making math problems from situations prepared by the teacher or students' experiences and developing math problems based on students' understanding and experience. In this activity, there are two important aspects, namely accepting and challenging. Acceptance relates to the ability of students to understand the situation given by the teacher or a predetermined situation. While challenging is related to the extent to which students feel challenged by a given situation to make math problems, There is an opportunity for students to be able to build their own knowledge by compiling questions and then solving them, making students' understanding of concepts develop and students become active in learning in class. This is in accordance with Hart's research in Silver, which suggests that problem posing is a window to enter into students' understanding of mathematical concepts (Silver, 1994).

Both learning models, both reciprocal teaching and problem posing, have their own characteristics and stages of learning in developing thinking processes and building understanding of mathematical concepts. The differences in the characteristics and stages of learning raise a number of advantages and disadvantages of each learning model that can affect students' ability to understand mathematical concepts. In order to determine which learning model is better suitable to be utilized as an alternative in school, research is required to evaluate the capacity to understand mathematical ideas between students who learn using reciprocal teaching and problem posing models. Based on the description presented, a study was conducted on two learning models that will be applied in building students' understanding of mathematical concepts.

METHOD

Population and Sample

The population in this study were all students of SMP Negeri 97 Jakarta in the odd semester of the 2015/2016 academic year. The sampling technique used is two-stage sampling. The first stage, namely purposive sampling. Purposive sampling is sampling that is carried out based on individual considerations to be adapted for research purposes (Purwanto & Sulistyastuti, 2011). Purposive sampling was chosen with the consideration that by choosing classes that study with the same teacher, the difference in results obtained is purely due to the difference in the treatment given. The second stage, namely cluster random sampling, Cluster random sampling is a way of taking samples from the population randomly where the population is divided into groups (Soewandi, 2012).

There are two mathematics teachers who teach in class VII SMP Negeri 97 Jakarta. Of the 7 classes that became the affordable population, 4 classes studied with teacher A and 3 other classes studied with teacher B. First, teacher B was chosen who taught 3 classes. Furthermore, the average similarity test was carried out with a one-way analysis of variance (ANOVA) test for the three classes to determine the initial condition of the class before being given treatment, namely by using the Mathematics Mid-Semester Examination (UTS) scores in the odd semester of the 2015/2016 academic year. Before carrying out the one-way ANOVA test, the normality and homogeneity test were carried out first as a condition for the one-way ANOVA test. The normality test uses the Liliefors test and the homogeneity test uses the Bartlett test. Based on the test results, it was concluded that the three classes came from populations that were normally distributed, homogeneous, and had the same average. After that, 2 classes were selected from 3 classes with the same initial conditions as the sample with a cluster random sampling technique to be used as experimental classes. The two selected classes were then determined as experimental class I and experimental class II, randomly. Each class experiment consisted of 36 students.

RESULT

Test Instrument

Before this research is conducted, the instrument will be tested. The study's validity tests included content validity, construct validity, and empirical validity tests. Content and construct validity were tested by lecturers and teachers. According to the validity calculations performed on 35 grade VII students in a different class, 5 questions are categorized as having a high level of validity, and 1 question is categorized as having a sufficient level of validity. Reliability test is also used in this study. The Cronbach Alpha formula was used to determine the instrument's reliability for interpreting students' mathematical concepts. The instrument reliability coefficient is 0.714, which places it in the high reliability category and allows it to be used as a measuring tool, according to reliability calculations performed on 35 seventh-grade students in another class.

Descriptive Statistics

Table 1 show descriptive statistical of the ability test for understanding mathematical concepts of the two classes after being given treatment.

TABLE 1. Descriptive Statistics of Ability to Understand Mathematical Concepts

Statistic	Experiment Class I (reciprocal teaching model)	Experiment Class II (problem posing model)
Number of students	36	36
Minimum Score	38.89	38.89
Maximum Score	94.44	88.89
Range	55.56	50
Modus	72.22	61.11
Mean	70.83	64.35
Varians	148.84	177.16
Standard Deviation	12.20	13.31
Lower Quartile (Q_1)	61.11	55.56
Median (Q_2)	72.22	63.89
Upper Quartile (Q_3)	77.78	72.22

According to Table 1, the average score on the test of mathematical concept understanding in experimental class I is greater than the average score on the test of mathematical concept understanding in experimental class II. According to the results of calculating the standard deviation of the two classes, experimental class II's standard deviation is higher than experimental class I's standard deviation. This means that the distribution of values in the experimental class II is more heterogeneous and the experimental class I is more homogeneous. Therefore, it may be concluded that students in experimental class I have more uniformly distributed mathematical understanding than students in experimental class II. The boxplot showed in Figure 1.

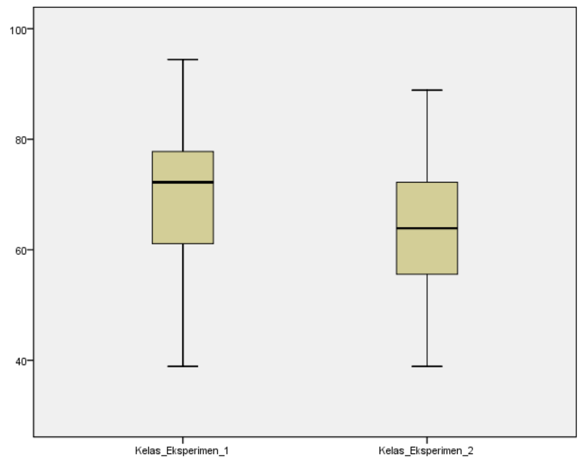

FIGURE 1. Boxplot of Students' Mathematical Concept Understanding Ability

Based on Figure 1, A horizontal line at the bottom of the rectangle in the boxplot indicates Q_1, Q_2 is indicated by a horizontal line at the inside of the rectangle, Q_3 is indicated by a horizontal line at the top of the rectangle, A horizontal line on the outside of the rectangle's top indicates the maximum value, and A horizontal line on the outside of the rectangle's bottom indicates the minimal value. Then, the vertical line in the rectangle is called the interquartile range and the two vertical lines outside the rectangle are called the whisker.

Based on Figure 1, several things can be compared, namely:

1. The values of Q_1, Q_2, Q_3 of the experimental class I are higher than the values of Q_1, Q_2, Q_3 of the experimental class II. The maximum value of the experimental class I is higher than the experimental class II, while the minimum value of the experimental class I is the same as the experimental class II.
2. In the experimental class I, the range between Q_1 and Q_2 and the range between Q_2 and Q_3 is not symmetrical. Q_2 is closer to Q_3 so the data is more concentrated between Q_2 and Q_3 and more spread out between Q_2 and Q_1. In the experimental class II, the range between Q_1 and Q_2 and the range between Q_2 and Q_3 is symmetrical. This is indicated by Q_2 which is in the middle of the box.
3. In the experimental class I, the whisker on the lower side is longer than the whisker on the upper side. This shows that the distribution of the data is uneven and the data is more spread out below Q_1. In the experimental class II, the whisker on the upper side is the same length as the whisker on the lower side, which means that the data distribution is evenly distributed.
4. There are no outliers in the two experimental classes so that the data distribution is relatively normal.

Data Analysis Prerequisite Test Before Treatment

a. Normality test

The normality test before treatment aims to determine the normality of 3 classes to be studied. With a significance level of $\alpha = 0.05$, the Liliefors test was used to test for normality. The data used is the value of the odd math mid-semester exam with the same material from the three classes. The test criteria are accepted H_0 if $L_0 < L_{table}$. Table 2 provides an overview of the normalcy test results.

TABLE 2. Recapitulation of Normality Test Calculation Results Before Treatment

Class	L_0	L_{tabel}	Information	Conclusion
I	0.113	0.150	$L_0 < L_{tabel}$	Accept H_0
II	0.111	0.148	$L_0 < L_{tabel}$	Accept H_0
III	0.074	0.148	$L_0 < L_{tabel}$	Accept H_0

Using the results of the three classes' odd midterm test scores, $L_0 < L_{table}$ with $\alpha = 0.05$. Thus, H_0 is accepted, which means that the odd midterm test scores from the three classes come from a normally distributed population.

b. Homogeneity Test

The homogeneity test before treatment aims to determine the homogeneity of 3 classes to be studied. The Bartlett test was used for this test, with a significance level of $\alpha = 0.05$. The data used is the value of the odd math mid-semester exam with the same material from the three classes. From the calculation results, it is obtained that $\chi^2 = 1{,}744$ with $\alpha = 0.05$ and dk= 3-1= 2 is obtained. The test criteria are to reject H_0 if $\chi^2 \geq \chi^2_{(1-\alpha)(k-1)}$. From the test results, it can be concluded that it is accepted because $\chi^2 = 1{,}744$ is less than $\chi^2_{(1-\alpha)(k-1)} = 5{,}991$. This means that the three classes tested have the same variance so that the three classes come from a homogeneous population.

c. Average Similarity Test

The average similarity test aims to determine the average similarity or initial conditions of the three classes before the treatment was carried out with the one-way ANOVA test with $\alpha = 0.05$. This test can only be carried out if the conditions for normality and homogeneity of variance are met. From the results of previous calculations, it can be seen that the test prerequisites have been met. The data used is the score of the odd math mid-semester exam with the same material from three classes.

TABLE 3. One-way ANOVA Test Preparation

Statistic	I	II	III	Total
N	35	36	36	107
Total X_i	2320,020	2226,670	2320,020	6866,710
Total X_i^2	159336,400	147488,845	153558,711	460383,956

Based on Table 3, calculations were made and obtained F_{count} = 0.948. With $\alpha = 0.05$, the dk of the numerator = dk(A) = 3-1= 2, and the dk of the denominator = dk(D) = 104. The test criteria are to reject H_0 if $F_{count} > F_{table}$. Because $F_{count} = 0.948 < F_{table} = 3.07$, then H_0 is accepted which means there is no significant difference to the average similarity or the three classes started from the same situation. The results of the ANOVA test did not show any difference, so there was no need to carry out further tests. Thus, from the three classes, two classes can be taken randomly as a sample.

Testing After Treatment

a. Normality test

Testing for normality after treatment used the Liliefors test at a significance level of $\alpha = 0.05$. The data used is the test score of students' ability to understand mathematical concepts on the subject of PLSV. The test criteria are accepted H_0 if $L_0 < L_{table}$. Table 4 provides an overview of the normality test's outcomes.

TABLE 4. Recapitulation of Normality Test Calculation Results After Treatment

Class	L_0	L_{table}	Information	Conclusion
Experiment I	0.094	0.148	$L_0 < L_{tabel}$	Accept H_0
Experiment II	0.098	0.148	$L_0 < L_{tabel}$	Accept H_0

The score of students' understanding of mathematical concepts on the topic of PLSV was obtained $L_0 < L_{table}$ with $\alpha = 0.05$, which indicates that H_0 is accepted. This shows that the data for both classes come from a normally distributed population.

b. Homogeneity Test

The homogeneity test was conducted to determine the t-test statistics to be used in hypothesis testing. Fisher's test was used to test for homogeneity with $\alpha = 0.05$. The test results for students' capacity to comprehend mathematical concepts from the two experimental courses were the homogeneity of the data examined. The test criteria are to accept H_0 if $F_{\left(1-\frac{1}{2}\alpha\right)(n_1-1,n_2-1)} < F_{count} < F_{\frac{1}{2}\alpha(n_1-1,n_2-1)}$. Based on the calculation of the students' mathematical concept understanding ability test scores, F_{count} = 0.840, $F_{((0.975)(35.35))}$ = 0.510 and $F_{((0.025)(35.35))}$ = 1.961. Because the value of F_{count} lies between 0.510 and 1.961, then H_0 is accepted at the significance level $\alpha = 0{,}05$. This means that both classes have the same variance, so the t-test statistic used is the t-test statistic with the same variance.

Statistical Hypothesis

The hypothesis in this study is formulated as follows:

$$H_0: \mu_1 = \mu_2$$
$$H_1: \mu_1 > \mu_2$$

μ_1 = the average score on the experimental class I test results (the ability to understand mathematical concepts of students who learn to use the reciprocal teaching model)

μ_2 = the average score on the experimental class II test results (the ability to understand mathematical concepts of students who learn to use the problem posing model)

H_0 = null hypothesis, the average result of the mathematical concept understanding ability test of students who learn to use the reciprocal teaching model is the same as the average result of the mathematical concept understanding ability test of students who learn to use the problem posing model.

H_1 = counter hypothesis, the average result of students' ability to understand mathematical concepts who learn to use the reciprocal teaching model is higher than students who learn to use the problem posing model.

Hypothesis Testing

The purpose of the study's hypothesis testing is to determine whether students who learn using the reciprocal teaching model have greater understanding of mathematical topics than students who learn using the problem-posing methodology. Hypothesis testing was carried out using t-test statistics with the same variance, namely at the significance level $\alpha = 0{,}05$ and degrees of freedom (dk) = $n_1 + n_2 - 2 = 36 + 36 - 2 = 70$. If $|t_{count}| \geq t_{table}$, then H_0 is rejected, this indicates that students who learn to utilize the reciprocal teaching model have a greater understanding of mathematical topics than students who learn to use the problem posing methodology. If $|t_{count}| < t_{table}$, then H_0 is accepted which means there is no difference in the ability to understand mathematical concepts of students who learn to use the reciprocal teaching model and students who learn to use the problem posing model. Based on the calculation results, the value of t_{count} = 2.153 is higher than the value of t_{table} = 1.667, then H_0 is rejected. This demonstrates that students who learn to use the reciprocal teaching model have a stronger understanding of mathematical topics than students who learn to use the problem posing model.

DISCUSSION

The purpose of this study is to ascertain whether students who learn to utilize the reciprocal teaching model have a greater understanding of mathematical topics than students who learn to use the problem posing model. This research was conducted in two class VII, namely experimental class I (reciprocal teaching learning model) and experimental class II (problem posing learning model). The time used in this study was 6 meetings consisting of 5 meetings for the application of learning models and 1 meeting for a test of the ability to understand mathematical concepts with the subject of one variable linear equation. After being given treatment, both classes were given a final test and the data obtained from the test results of the ability to understand mathematical concepts were calculated using t-test statistics.

Based on the results of hypothesis testing with t-test statistics, the value of t_{count} = 2.153 is higher than the value of t_{table} = 1.667, then H_0 is rejected, which means the ability to understand mathematical concepts of students who learn to use the reciprocal teaching model is higher than students who learn to use the problem posing model. In the class that studied with the reciprocal teaching model, the range was 55.56 with the lowest score of 38.89 and the highest score of 94.44. There are 20 students who have achieved the KKM score for mathematics, which is 68. Meanwhile, the results of the test for the ability to understand mathematical concepts in the class that studied with the problem posing model obtained a range of 50 with the lowest score of 38.89 and the highest score of 88.89. There are 12 students who have achieved the KKM score for mathematics, which is 68. The average score of students who study using the reciprocal teaching model is 70.83 higher than students who learn to use the problem posing model, which is 64.35.

The difference in the results obtained from the two learning models occurs because of differences in treatment in the learning process, namely:

1. Learning Stages

   The learning stages in reciprocal teaching begin with discussing the teaching materials received by students, then students make questions that will be asked to other groups based on the teaching materials received (question generating) and the designated group must answer the questions posed. Next, the teacher provides clarification (clarifying) regarding the group's answers given. After the teacher feels that the students are starting to discover and know the concepts being studied, the teacher gives a Student Worksheet (LKS) to be completed (predicting). Students exchange opinions, knowledge, and help each other in solving the problems given. After students complete the worksheet, representatives from the group come forward to write and explain the answers in front of the class. The teacher gives a response in the form of confirmation of the students' answers and presentations. At the end of the lesson, students summarize the PLSV concepts they have learned (summarizing).

   This situation is different in the class that learns by using problem posing. The learning stages in problem posing begin with an explanation of the subject made by the teacher, in this case there is also a question-and-answer discussion between the teacher and students. Next, the teacher presents a situation related to the PLSV subject, then the teacher gives the opportunity for students to ask questions related to the given situation. Next, the teacher and students choose the questions that are considered the most interesting to solve. Then the students in groups answer the possible answers/solutions that are known by the students with the guidance of the teacher. Both of these activities are included in the accepting stage.

   After the teacher feels that the students have understood how to ask questions, the teacher gives the Student Worksheet (LKS). Students exchange opinions in groups and arrange questions related to the given situation or change old questions that have been worked on into new questions. Then students answer the questions that have been made by discussing with the group. After that, several group representatives presented the problems that had been obtained and asked other groups who did not come forward to try the problem. Next, the teacher collects the students' work and confirms the students' answers.

2. Teacher's Role

   The teacher's role in this research is only to help stimulate the mindset and shape students' initial knowledge. In elaboration activities, the teacher only guides students as necessary only if students need help in the group discussion process. Then, at the end of the lesson the teacher confirms to discuss the problems that are still not understood by the students and provide clarification about the results of the student's work. However, there are differences in the teacher's role in exploratory activities in the reciprocal teaching and problem posing learning models. In the problem posing learning model, the teacher explains the topic of the lesson in general, such as definitions and gives examples of how to ask questions from the available situations, while the teacher's role in the reciprocal teaching learning model is only as a student facilitator to discuss the teaching materials provided.

3. Group Discussion

   The reciprocal teaching learning model facilitates students to discuss twice, namely when studying teaching materials and working on worksheets. Students in discussing teaching materials can discuss and exchange ideas with group members. When working on worksheets, students exchange opinions, knowledge, and help each other in solving the problems given. The group discussion process in the reciprocal teaching learning model at first did not go well. However, at the next meeting, students began to get used to it and were able to adjust so that the discussion activities could run well.

This is different from the problem posing learning model which facilitates students to discuss once, namely when working on worksheets. Students exchange opinions in groups and arrange questions related to the given situation or change old questions that have been worked on into new questions. However, the group discussion process did not go well. Although students have been shown how to ask questions to understand the given situation and strategies for preparing questions to be asked, there are still students who do not work and hand over responsibility to their groups. This makes the discussion activities not run well.

4. Time Required

The reciprocal teaching learning model takes longer than problem posing. The existence of 4 stages in reciprocal teaching, namely question generating, clarifying, predicting, and summarizing spends more time than problem posing which consists of 2 stages, namely accepting and challenging. The consequence is that the LKS processing time in the reciprocal teaching learning model is shorter than the problem posing learning model. However, such conditions make students who learn to use reciprocal teaching concentrate fully on the questions given so that there is no time for jokes or unclear conversations.

When viewed from the stages of learning, the role of the teacher, group discussions, and the time required, it can be seen that both the reciprocal teaching and problem posing learning models can develop students' ability to understand mathematical concepts. However, when the two are compared, the reciprocal teaching learning model is superior to the problem posing learning model. Therefore, it is not surprising that the ability to understand mathematical concepts of students who learn to use the reciprocal teaching learning model is higher than the ability to understand mathematical concepts of students who learn to use the problem posing learning model.

CONCLUSION

Understanding mathematical concepts is one thing that must be mastered by every student. This study compare two models, namely reciprocal teaching and problem posing model. It can be concluded that there are differences in the ability to understand mathematical concepts between students who learn to use reciprocal teaching learning models and students who learn to use problem posing learning models, namely the ability to understand mathematical concepts of students who learn to use reciprocal teaching learning models is higher than students who learn to use the problem posing learning model at SMP Negeri 97 Jakarta on the subject of PLSV.

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